König, C. (1960): Einflüsse von Licht und Temperatur auf den Winterschlaf des Siebenschläfers *Glis glis* (Linnaeus, 1766). Z. Morph. Ökol. Tiere **48**, 545–575.
Piekarzewska, A. B. (1977): Changes in thermogenesis and its hormonal regulators during the postnatal development of rabbits and guinea pigs. Acta theriol. **22**, 159–180.
Poczopko, P. (1979): Metabolic rate and body size relationships in adult and growing homeotherms. Acta theriol. **24**, 125–136.
Vietinghoff-Riesch von, A. (1960): Der Siebenschläfer (*Glis glis* L.). Stuttgart: G. Fischer Verlag. 1–196.

Author's address: Doz. Dr. Marek Gębczyński, Mammals Research Institute, 17–230 Białowieża, Poland

Food and habitat of badgers (*Meles meles* L.) on Monte Baldo, northern Italy

By H. Kruuk and Lil de Kock

Institute of Terrestrial Ecology, Banchory, Scotland

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Abstract

Studied the food of European badgers *Meles meles* in northern Italy using faecal analysis, and vegetation and altitude used by badgers in different seasons. Both volume and frequency of occurrence of different foods were quantified; at all times of year, fruits, especially olives, were most important (62 % in volume), but earthworms, arthropods, gasteropods and various vertebrates were also taken. High altitude regions were used only in summer, probably to exploit earthworm populations; the low-lying olive zone was used at any time. The distribution of these resources was likely to determine the badgers' range sizes.

Introduction

This paper describes the food of badgers (*Meles meles* L.), as determined by faecal analysis, in a study area on the slopes of Monte Baldo, northern Italy; it also describes seasonal fluctuations in food and food availability, seasonal foraging at different altitudes, and the boundaries of badger territories.

The Monte Baldo area is biologically important because of its rich flora and fauna, and this badger study was prompted by the threat of road construction which would separate the lower slopes from the higher ones. This might affect the badgers which are numerous in the area. In addition, knowledge of the badgers' feeding ecology here is important for a comparison with studies in north-western Europe, where the species is usually a specialist feeder on earthworms (*Lumbricus* spp.; Andersen 1955; Skoog 1970; Bradbury 1974; Wiertz 1976; Kruuk 1978a; Kruuk and Parish in press a) which are relatively uncommon in the Monte Baldo area. Earlier studies have discussed the relationship between the local distribution of the badgers' main food and their spatial organisation (Kruuk 1978a; Kruuk and Parish in press b), and the Monte Baldo study area offered a chance to look at this relationship in a very different environment.

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Study area

The slopes of Monte Baldo extend from the level of Lago di Garda, at 60 metres above sea level, up to 2,200 m. The study area is located on the lower slopes (fig. 1), as signs of badger activity were only rarely found higher up. The zoning of vegetation in the study area is characteristic for the entire western slope of Monte Baldo (Wolfsberger 1971). The lower part of the olive zone has a dense human habitation and several roads; olive *(Olea europea)* groves have a ground cover of grass, used mostly for hay, and near the houses and scattered ruins are cultivated cherries *(Prunus avium)*, figs *(Ficus carica)*, grapes *(Vitis vinifera)*, apples *(Malus domestica)*, plums *(Prunus domestica)*, medlar *(Mespilus germanica)* and other fruit trees. The olive groves are several thousand years old.

The macchia consists of dense shrubby woodland, dominated by hop hornbeam *(Ostrya carpinifolia)*, sessile oak *(Quercus petraea)*, manna ash *(Fraxinus ornus)* and cornelian cherry *(Cornus mas)*; there are few houses or ruins, some of which have cherry trees. In the beech zone the most common trees are beech *(Fagus sylvaticus)*, juniper *(Juniperus communis)*, spruce *(Picea abies)* and cherry, and there are patches of grassland which are grazed in summer. In the alpine grazing area the most common shrubs and trees are mountain pine *(Pinus mugo)* and alpine roses *(Rhododendron* spp.). In these zones, and also between them, there are areas dominated by hazel *(Corylus avellana)*, a pine plantation *(Pinus nigra)* and grassy groves of sweet chestnut trees *(Castanea sativa)*.

Average precipitation is heaviest in May and October, and varies between about 100 cm at lake level to 120 cm in the highest part of the study area (Turri 1971). The area above approximately 1000 m is mostly covered in snow from November to April, but snowfall is rare at lake level.

Methods

Between October 1979 and October 1980, 223 badger faeces were collected from the characteristic badger "latrines" in all parts of the study area. They were stored in polythene bags and preserved with kitchen salt then analysed in the laboratory as described by Kruuk and Parish (in press a). In summary, each sample was washed through a 1.3 mm mesh sieve, and the sediment in the rinsing water was inspected under the microscope for the presence of earthworm chaetae. The washed sample

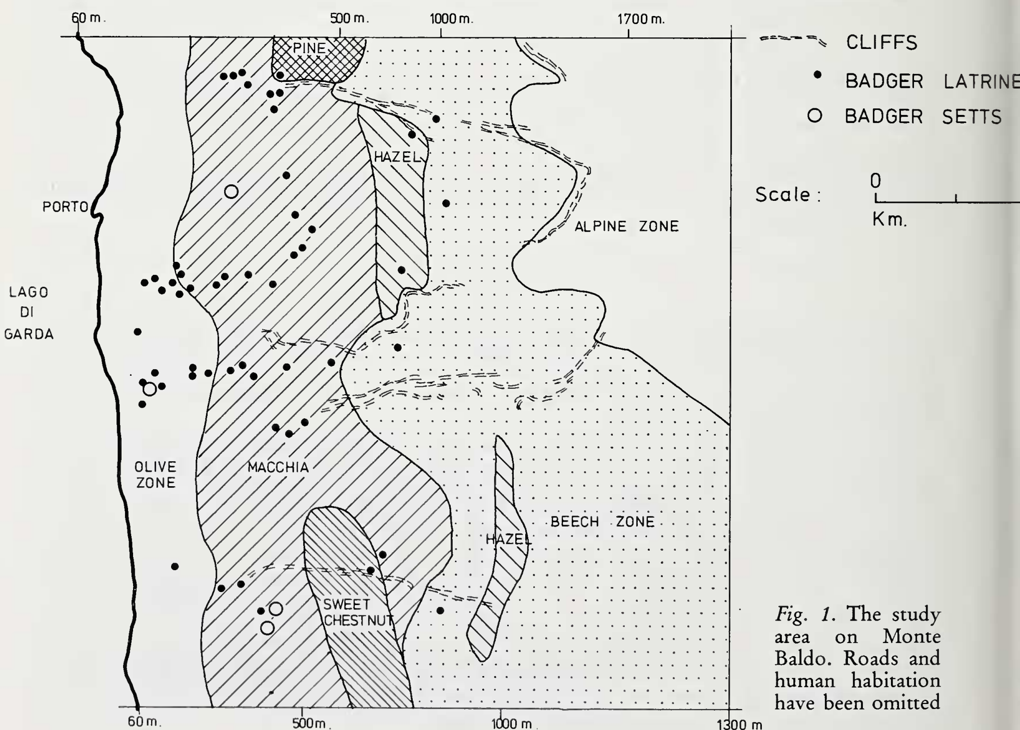


Fig. 1. The study area on Monte Baldo. Roads and human habitation have been omitted

was examined in a large white dish and the total numbers of each kind of prey or fruit were counted or estimated. Earthworm numbers were assessed from the number of gizzard rings (Bradbury 1977) or from the correlation between chaetae and gizzard rings in each dropping (Kruuk and Parish, in press a). All other items were identified by comparisons with reference material.

An attempt was made to reconstruct what the badger had eaten, using the numbers and relative size of items found in the faeces. The relative bulk of each prey or fruit in the food intake of the badger was estimated by multiplying the number of remains found in the faecal sample by the estimated bulk of each item when eaten. For example, a medium sized beetle, an earthworm and an olive were estimated to have the same bulk when eaten, although the quantity of their remains in the faeces was very different.

The estimated relative volume of each kind of food ingested was scored for each sample on a seven point scale as absent, ≤ 5 %, 6–25 %, 26–50 %, 51–75 %, 76–95 %, ≥ 96 %. In the final evaluation of ingested volume the mean values of these categories were used.

The location of badger latrines and setts was mapped during intensive searches throughout the year, and notes were made of the use of latrines and other badger activities in different seasons. Notes were also made of the time of ripening of various fruits at different altitudes.

Results

Food

Figure 2 shows the frequency of occurrence and relative volume of food categories in the combined samples over the whole year. The figure shows the estimated relative volume of each food in the badger's food-intake for whenever it occurred in the faeces (Y), against the percentage of faeces in which the food occurred (X); therefore $\frac{X \times Y}{100}$ equals the percentage volume of each food in the overall diet, and points with equal X x Y values are connected by a set of hyperboles. In fig. 2 the point representing fruits is well beyond the 50 % volume line (estimated overall volume in the food 62 %), showing that fruit occurred in almost 90 % of the faeces (X), and when it did occur it occupied an estimated 70 % of

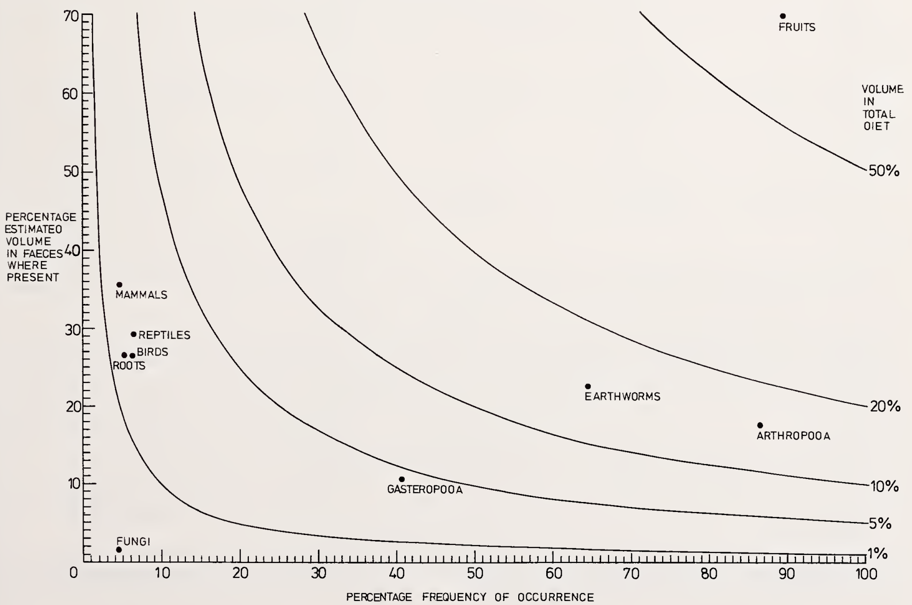
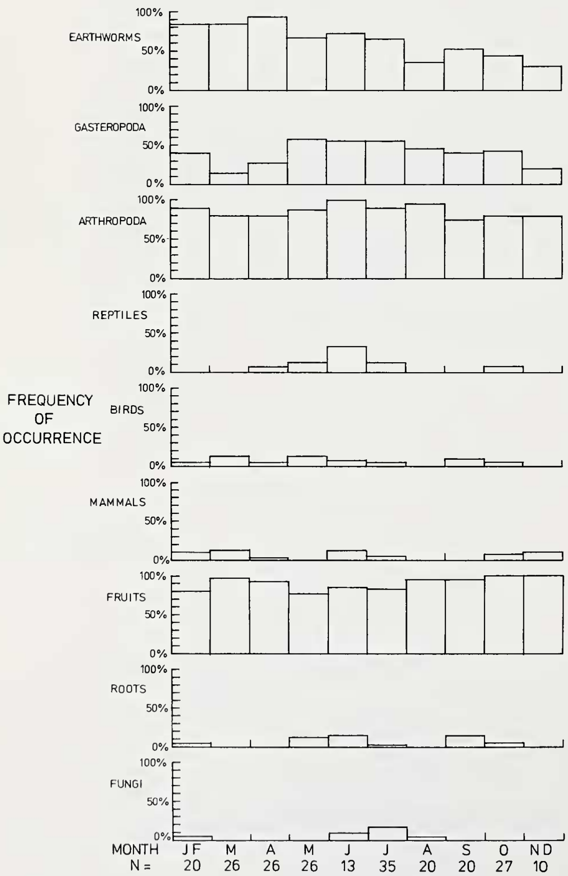


Fig. 2. Estimated volume of food category whenever it was eaten, versus the frequency of occurrence in all faeces. Hyperboles connect points of equal relative volume in the overall diet of the badger

ingested food volume (Y). Earthworms (Lumbricidae) and arthropods were of equal overall importance (14 % and 15 % respectively), but far less so than fruits; all other foods were rather insignificant either because they were taken in small quantities (Gasteropoda) or infrequently (mammals, reptiles, birds and roots) or both (fungi).

Fig. 3 shows the frequency of occurrence of each of these food categories for different months. Fruit was found in the faeces of all months and very frequently, and so were arthropods; earthworms were less common in the second half of the year, whilst gasteropods and reptiles occurred most commonly in the summer months, and the other foods showed little seasonal differentiation. Thus, the three food categories which were of greatest overall importance (fig. 2) were eaten throughout the year.

It is worthwhile to break down some of the food categories into various food species. Analysis of the seasonal occurrence of different fruits, for instance, shows that only olives were present in all months (fig. 4), especially in the first half of the year with a second peak in September; the relative scarcity of olives in mid-summer and the end of the year is compensated by cherries and figs, respectively. The mean number of olive stones, per dropping in which olives were present, was 11.8 ± 13.0; for cherries this was 23.2 ± 19.9, but the number of figs could not be estimated. It happened fairly frequently that in a



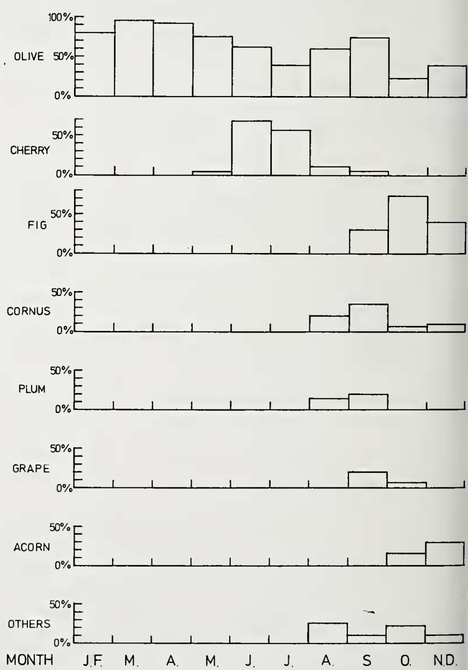


Fig. 3 (left). Percentage occurrence in badger faeces of various categories of food, in different months.
Fig. 4 (right). Percentage occurrence in badger faeces of various fruits, in different months

sample olive remains were found without the stones; perhaps not all olive stones were ingested.

Lumbricidae could not be further identified. Amongst the arthropods we recognised caterpillars (Lepidoptera, in 17 % of the samples), other larvae (in 11 %), beetles, cockroaches and crickets (Coleoptera, Blatteroidea, Orthoptera in 78 %), centipedes (Scolopendridae, in 15 %) and others (in 5 %). Of these, beetles etc. occurred at all times but less in mid-winter, centipedes were eaten almost only in winter, and others were rather non-seasonal.

Of the gastropods, slugs occurred in 19 % and snails in 33 % of the faeces, with no clear seasonal pattern. Reptiles were probably all lizards (Lacertilia), and mammals were mostly small rodents, insectivores and one lagomorph. Bird remains included several eggs, feathers were mostly of blackbird *(Turdus merula)*, one owl (probably the long-eared owl *Asio otus* and its egg) and poultry. "Roots" were one or more species of bulb, and "fungi" included only subterranean species.

At least some of the seasonal variation in the badger food was associated with food availability. Olives fell off the trees especially from January to March, but even as early as November and until May, and they decomposed very slowly so could be found at any time of year. The first cherries were ripe in early June at the lower end of the study area and in late July at the higher altitudes. All other fruits important to the badger ripened in August–October.

In the study area earthworms occur in high density only in some small patches in the beech zone and the alpine grazing zone, where with "formalin-sampling" (Raw 1959; Satchell 1967; Brown in press), we found as many as 19 and 10 earthworms larger than 8 cm in two $^1/_4$ m^2 plots (and 32 and 12 smaller ones). None was found in four other plots in the alpine grazing area, and in eight plots in the olive groves and the macchia only an

Table 1

Use of badger latrines at different altitudes

Percentage of latrines in use	Altitude Below 400 m	 400–800 m	 Above 800 m
May–October	60 (n = 33)	89 (n = 43)	82 (n = 17)
November–April	87 (n = 61)	58 (n = 38)	0 (n = 30)
$X^2 = 33.0$; df = 2; $p < 0.001$			

Table 2

The presence of earthworm remains in badger faeces from different altitudes, May to October

Percent of samples	Earthworms Present, volume over 25 %	 Present, volume less than 25 %	 Absent	 Total
Altitude Above 800 m	43 %	39 %	17 %	99 % (n = 23)
Below 800 m	12 %	38 %	50 %	100 % (n = 118)
$X^2 = 16.0$; df = 2; $p < 0.001$				

occasional small earthworm was encountered. Badgers will probably meet occasional earthworms in the leaf-litter at all times of the year except in the hot and dry summer months, but at that time they have access to the "worm-patches" in the alpine grazing areas which in winter are covered in snow. The badger latrines above 800 m (mostly at 1000–1100 m) were used exclusively in summer (table 1), and the faeces from those latrines contained significantly more earthworm remains than those from lower down in the same period (table 2). It was interesting, however, that 22 % of the high-altitude faeces also contained olive-remains, suggesting that at times badgers were foraging at least 800 m lower down and then came up again.

Distribution of latrines and setts

In fig. 1, the location of latrines has been indicated. Obviously we only found a proportion of them, but there appeared to be trends in the distribution of these latrines. It has been shown elsewhere that badger latrines are located especially on territorial boundaries (Kruuk 1978b), and although it has not been possible to confirm this at Monte Baldo, the location of latrines together with the course of high cliffs, suggested that these boundaries ran in the direction of the slope; in other words, badgers had access to high as well as low ground within the confines of their ranges. Only few of the badger setts were found, because of the dense undergrowth and many large boulders; the approximate location of others, not shown in fig. 1, could sometimes be guessed from the direction of badger paths and indications by local farmers. In general, the distribution of these setts and of the latrines suggests a spatial organisation similar to that of badgers elsewhere (Kruuk 1978b; Kruuk and Parish in press b), but more information is needed.

Discussion

Our data suggest that on Monte Baldo, as in north-western Europe, badgers are food specialists; in NW Europe they specialise in earthworms (*Lumbricus* spp., Kruuk and Parish in press a), here in fruits, especially olives. Olives are unusual fruits in that they are available throughout the year, and they have a high fat content; it is likely that these characteristics make them a reliable staple food for the badger. The data from the faecal analysis also show the dependence of badgers on agriculture; this, too, has a parallel in NW Europe. Badgers are relatively common in the Monte Baldo region, and this may well be largely due to their utilisation of olives, which have been grown there for many centuries and in large quantities. At the same time earthworms have some importance in the diet, especially in summer when the higher altitudes can be exploited; it is likely that the vertical extent of the badgers' ranges is dependent, at least in some measure, on access to the earthworm sites and to late-ripening cherries, as well as to the low-lying olive groves. This is consistent with the suggestion that the size of badger ranges elsewhere is determined by the distribution of food resources (Kruuk and Parish in press b). For conservation management of badger populations on Monte Baldo, the dependence of badgers on high as well as on low ground is an important feature; separation, for instance by a large main road, would probably be highly disruptive.

Acknowledgements

We are grateful to Drs. D. Jenkins and M. P. Harris for helpful comments on the manuscript.

Zusammenfassung

Nahrung und Habitat vom Dachs (Meles meles L.) am Monte Baldo, Norditalien

In einer Gebirgsregion Norditaliens wurden an Kotproben von Dachsen *(Meles meles)* Untersuchungen durchgeführt. Quantitative Analysen haben ergeben, daß im Jahresablauf Früchte zu allen Zeiten eine besonders große Rolle spielen, vor allem Oliven. Zusätzlich konnten Regenwürmer, Arthropoden, Gastropoden und verschiedene kleinere Vertebraten nachgewiesen werden. Ferner deutet die Verteilung der Gruppenkotplätze darauf hin, daß sich die Wohngebiete der Dachse von 80 m bis über 1000 m Höhe erstrecken. Diese große Ausdehnung mag an das zonale Vorkommen der Nahrung gebunden sein. Höher gelegene Gebirgsregionen werden nur im Sommer, die tiefer gelegenen Olivenhaine werden hingegen ständig aufgesucht.

References

ANDERSEN, J. (1955): The food of the Danish badger *(Meles meles danica)* with special reference to the summer months. Dan. Rev. Game Biol. **3**, 1–75.

BRADBURY, K. (1974): The badgers' diet. In: Badgers of Yorkshire and Humberside. Ed. by R. J. PAGET and A. L. V. MIDDLETON. York: Ebor Press. 113–125.

— (1977): Identification of earthworms in mammalian scats. J. Zool. Lond. **183**, 554–555.

BROWN, C. A. J. (in press): Prey abundance of the European badger, *Meles meles* L., in North-East Scotland. Mammalia.

KRUUK, H. (1978a): Foraging and spatial organisation of the European badger, *Meles meles* L. Behav. Ecol. Sociobiol. **4**, 75–89.

— (1978b): Spatial organization and territorial behaviour of the European badger *Meles meles*. J. Zool. Lond. **184**, 1–19.

KRUUK, H.; PARISH, T. (in press a): Feeding specialisation of the European badger *Meles meles* in Scotland. J. Anim. Ecol.

— (in press b): Factors affecting population density, group size and territory size of the European badger, *Meles meles* L. J. Zool. Lond.

RAW, F. (1959): Estimating earthworm populations by using formalin. Nature **184**, 1661–1662.

SATCHELL J. E. (1967): Lumbricidae. In: Soil biology. Ed. by A. BURGESS and F. RAW. London and New York: Academic Press. 259–322.

SKOOG, P. (1970): The food of the Swedish badger, *Meles meles* L. Viltrevy **7**, 1–120.

TURRI, E. (1971): Il Monte Baldo. Verona: Edizione Corev.

WIERTZ J. (1976): De voedsel ecologie van de das (*Meles meles* L.) in Nederland. Rijks Instituut voor Natuurbeheer Report, 79/9, Leersum, The Netherlands.

WOLFSBERGER, J. (1971): Die Macrolepidopteren-Fauna des Monte Baldo in Oberitalien. Museo Civico de Soria Naturale, Verona.

Authors' addresses: Dr. HANS KRUUK, Institute of Terrestrial Ecology, Banchory, AB3 4BY, Scotland; Dr. LIL DE KOCK, Brenzone/Boccino (V.R.), I-37010

Die Bedeutung des Schnüffelns für das Riechen des Hundes

Von W. NEUHAUS

Eingang des Ms. 3. 2. 1981

Abstract

The importance of sniffing for the olfaction of the dog

Sniffing of dogs consists of a series of six to twenty shorts puffs of inspiration followed by one exspiration. During a single puff of inspiration no whirles are formed in the space between the Ethmoidalia because the Reynold's number for turbulent flow under the given conditions remains below the critical value.

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